Improving the Long-term Homogeneity in MERRA Reanalysis for Climate study

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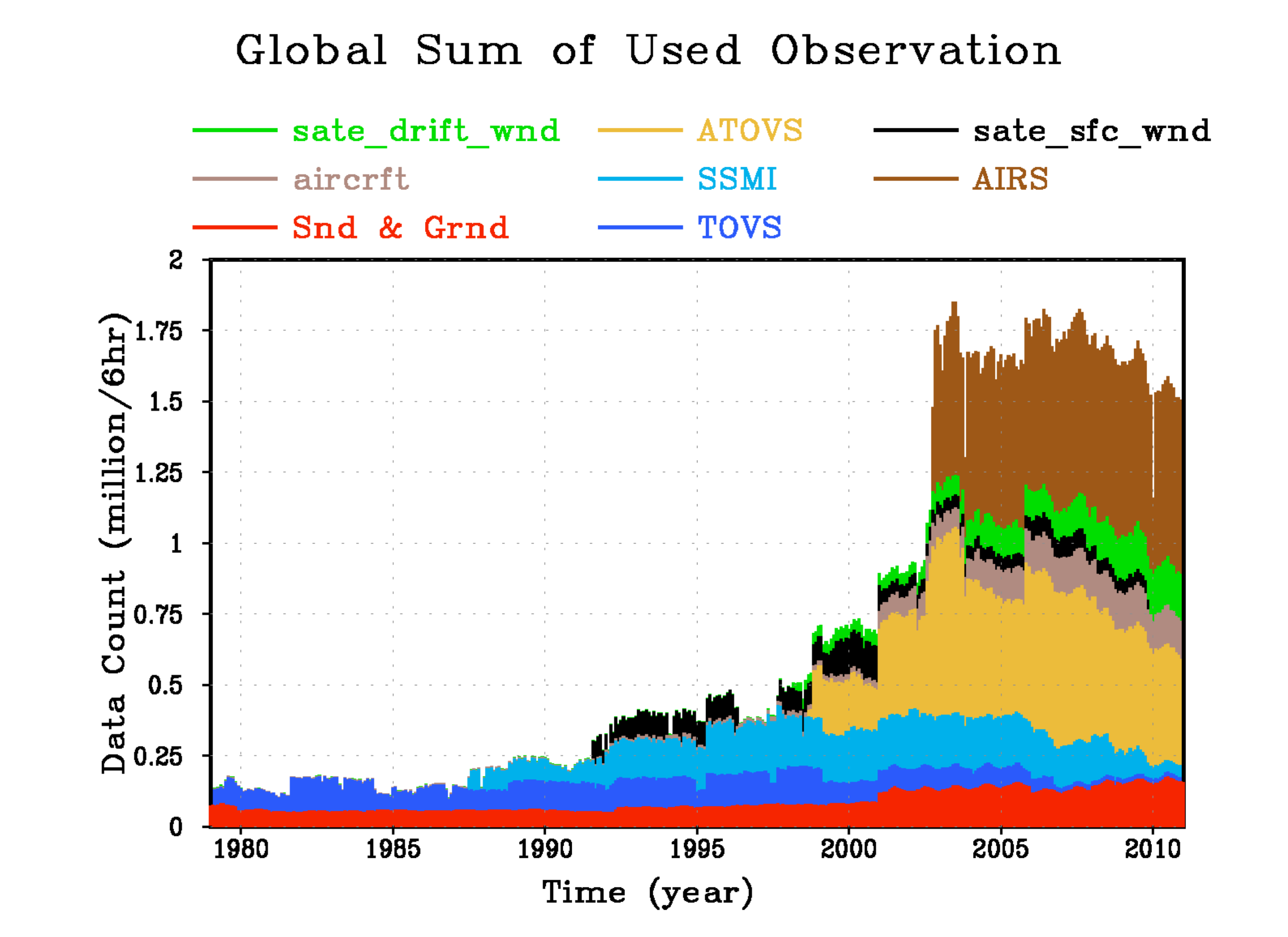
Like other reanalysis datasets, MERRA (Modern Era Retrospective-analysis For Research And Applications), was initiated for climate study, but the issue of temporal inconsistency impedes the full realization of this goal.

Ideally, when a reanalysis dataset is produced, if both observation and model simulation are not biased, the long-term temporal consistency would be obtained.

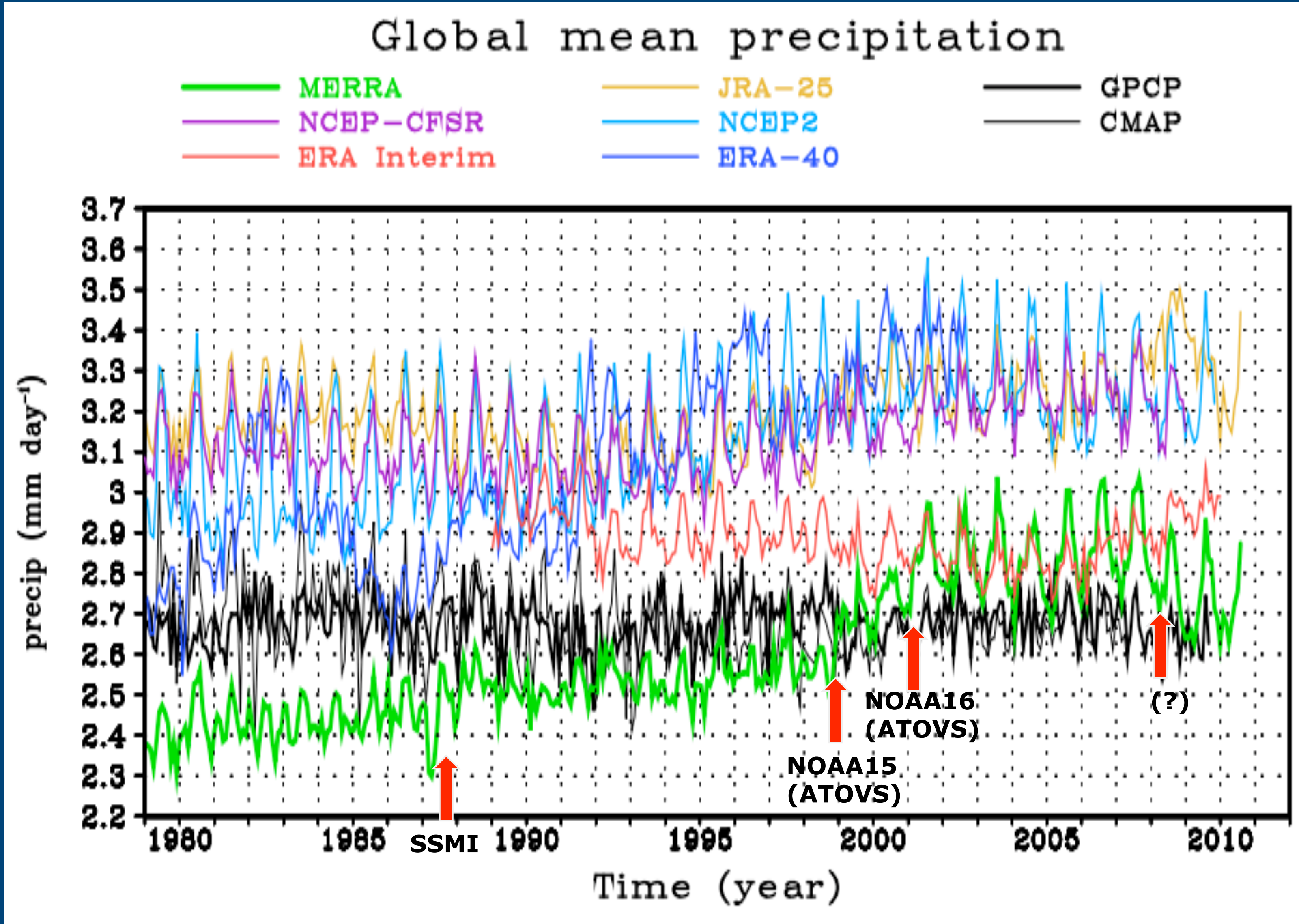
In reality, both observation and model are more or less biased. As the global observing system changes along the time, the homogeneity is hard to be kept, even with fixed model and analysis scheme.

The Evolution of the Global Observing System

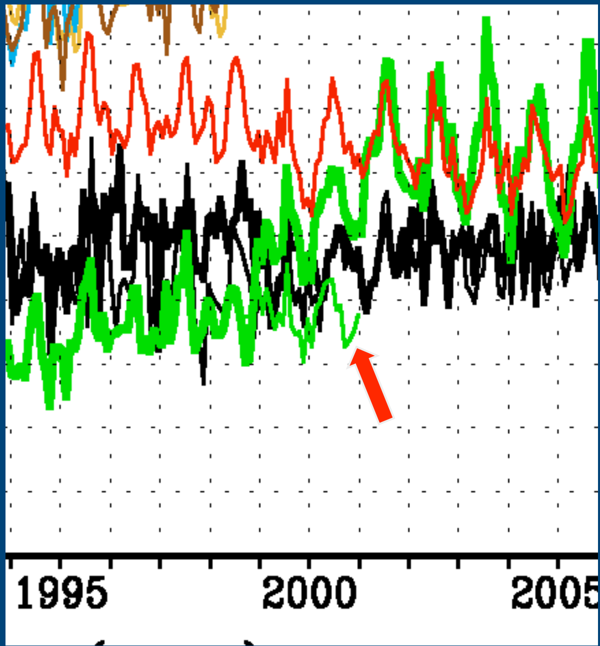


RIENECKER et al., 2011

The impact of changing observing system in reanalyses



Case study: the impact of NOAA15 (ATOVS)



A two year Reduced Observing System Segments (ROSS) withholding the NOAA-15 ATOVS radiance data has been produced to address the impact of the introduction of ATOVS data in late 1998.

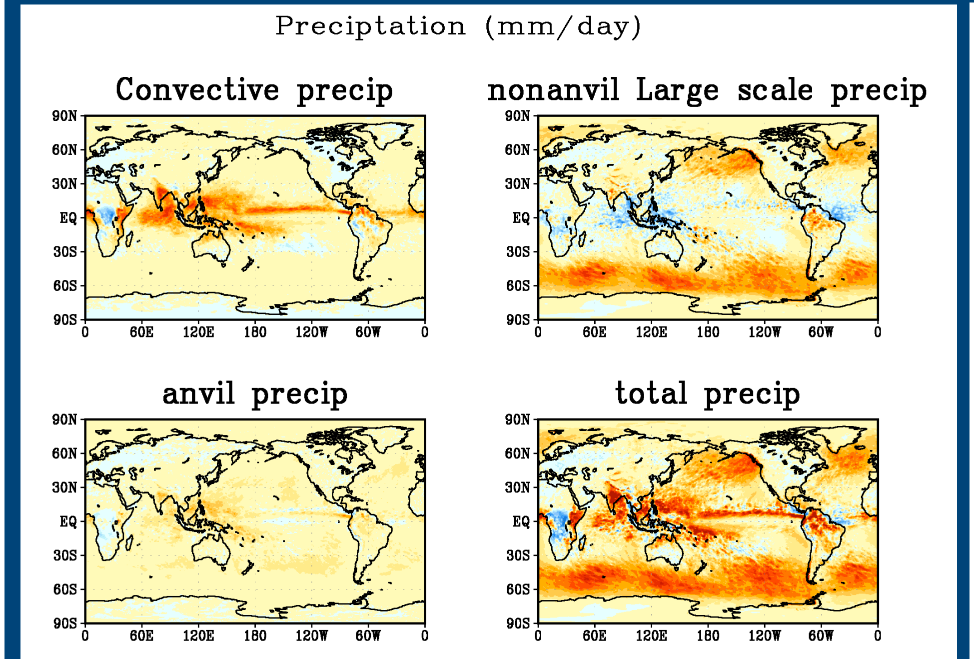
This reanalysis segment is a natural continuation of MERRA at the time before NOAA-15 ATOVS data is added, except that the new NOAA-15 data that comes along will not be assimilated. By comparing the original MERRA data with this NOAA-15_withholding reanalysis segment, a systematic picture of the NOAA-15 impact has been obtained.

- Associated with the introduction of NOAA-15, the humidity in the lower free atmosphere increases. At the same time, the moisture increment increases and results a increasing of precipitation.

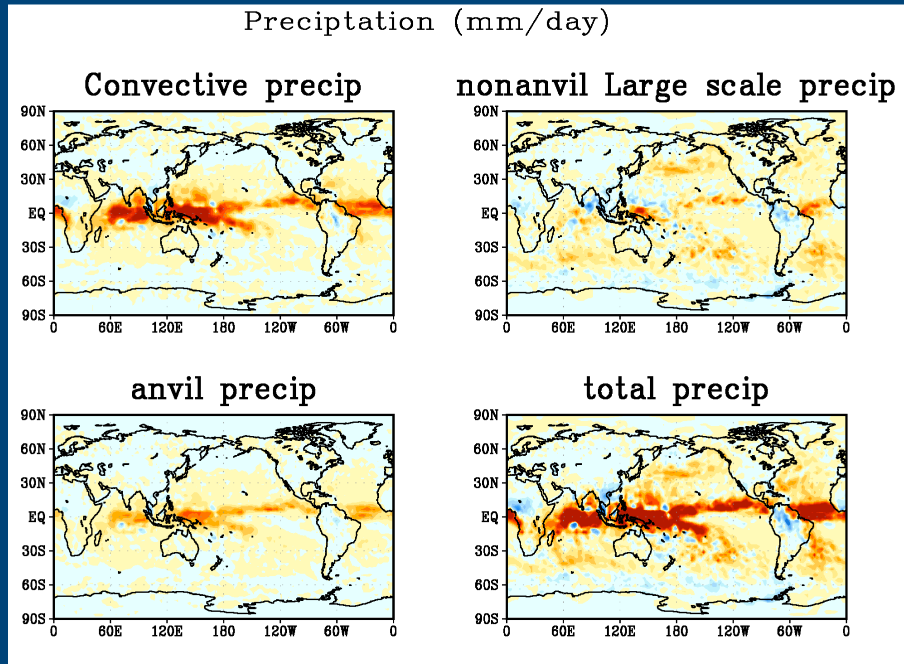
- The additional precipitation releases latent heat, which is almost offset by the negative change of temperature increment, although not at the same location. This drives the large scale overturning circulation and changes the temperature field over high latitude and high altitude region.

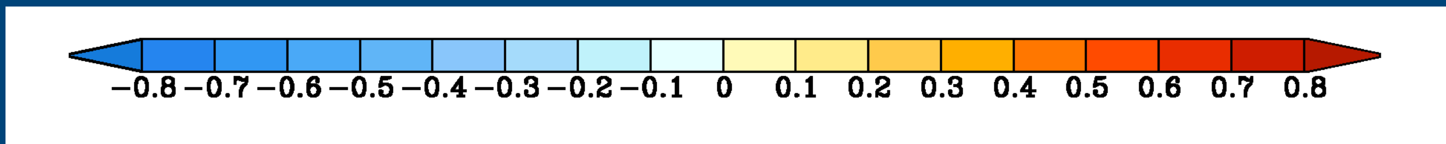
The impacts of NOAA15 (ATOVS) and SSM/I are largely different

NOAA15 (ATOVS)



SSM/I





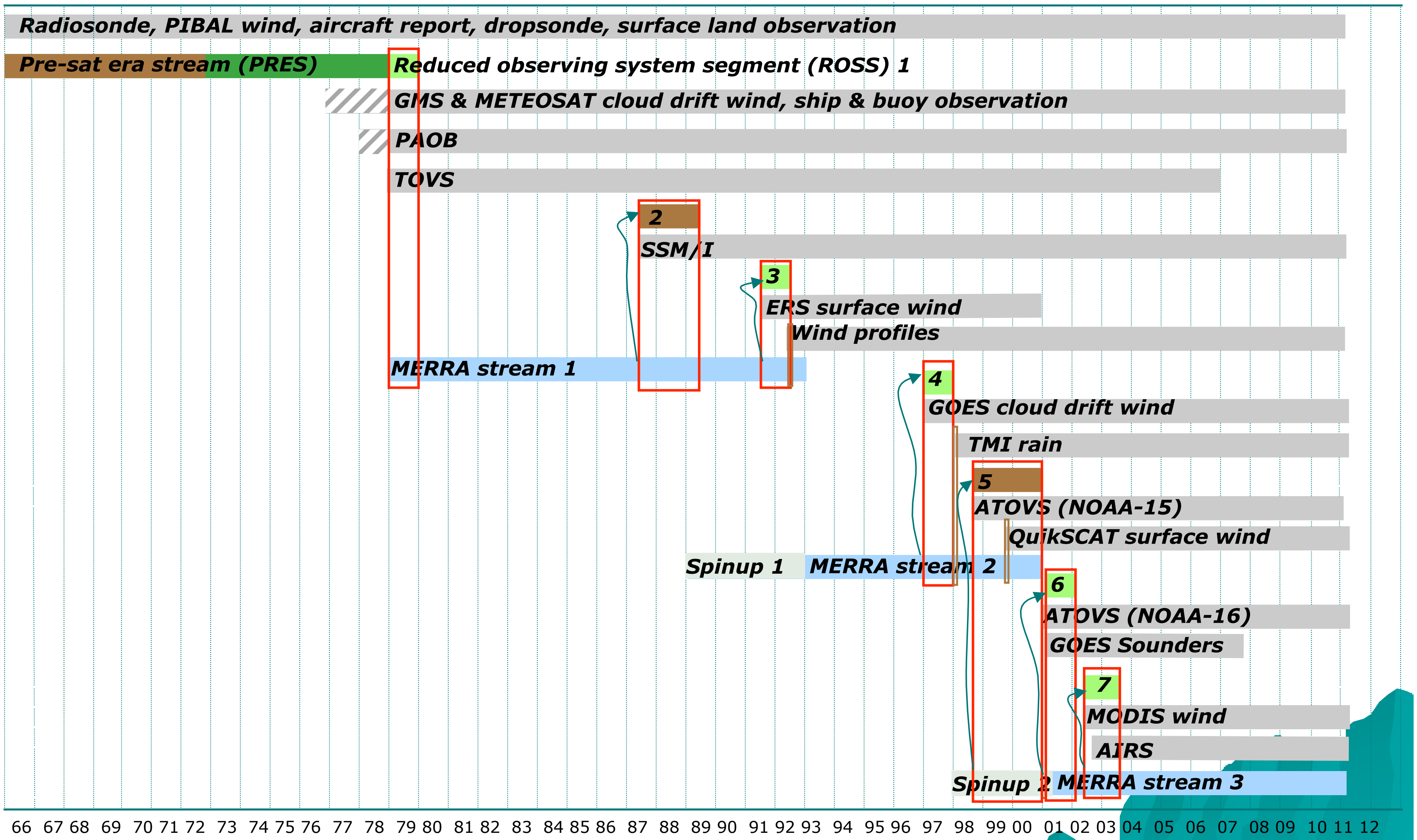
The plan of MERRA Homogenization

- Produce Reduced Observing System Segments (ROSS) of assimilation withholding new observation types when they are introduced in the MERRA data stream.

- By comparing a ROSS with the corresponding MERRA data segment, the impact of the related observation type can be cleanly isolated.

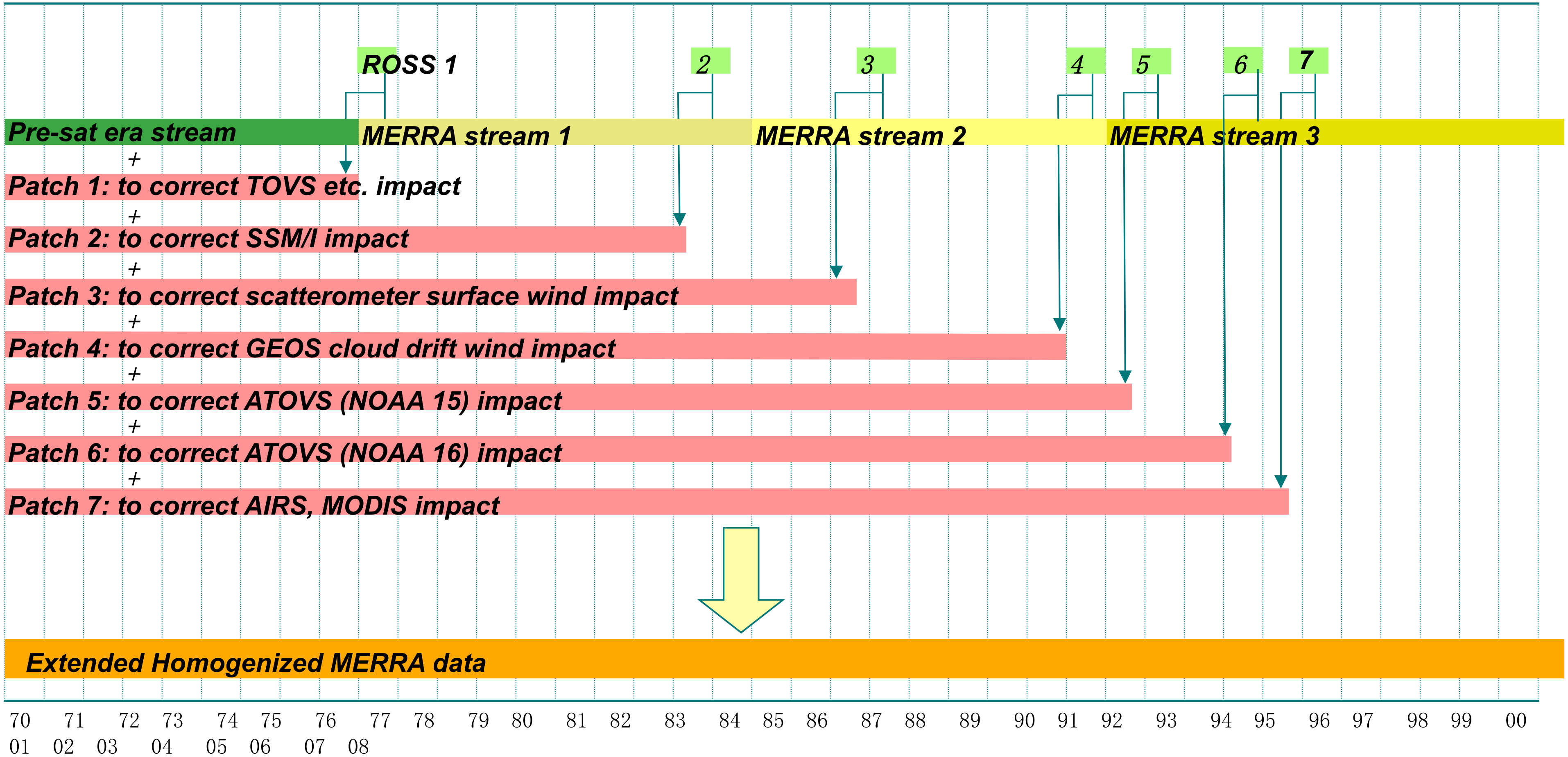
- The obtained information of the impacts will be used to generate patches to homogenize MERRA.

ROSSes to Address the Impacts of Introductions of New Observation Platforms



Grey: observations; Blue: MERRA streams; Brown: ROSSes done; Green: ROSSes to be done

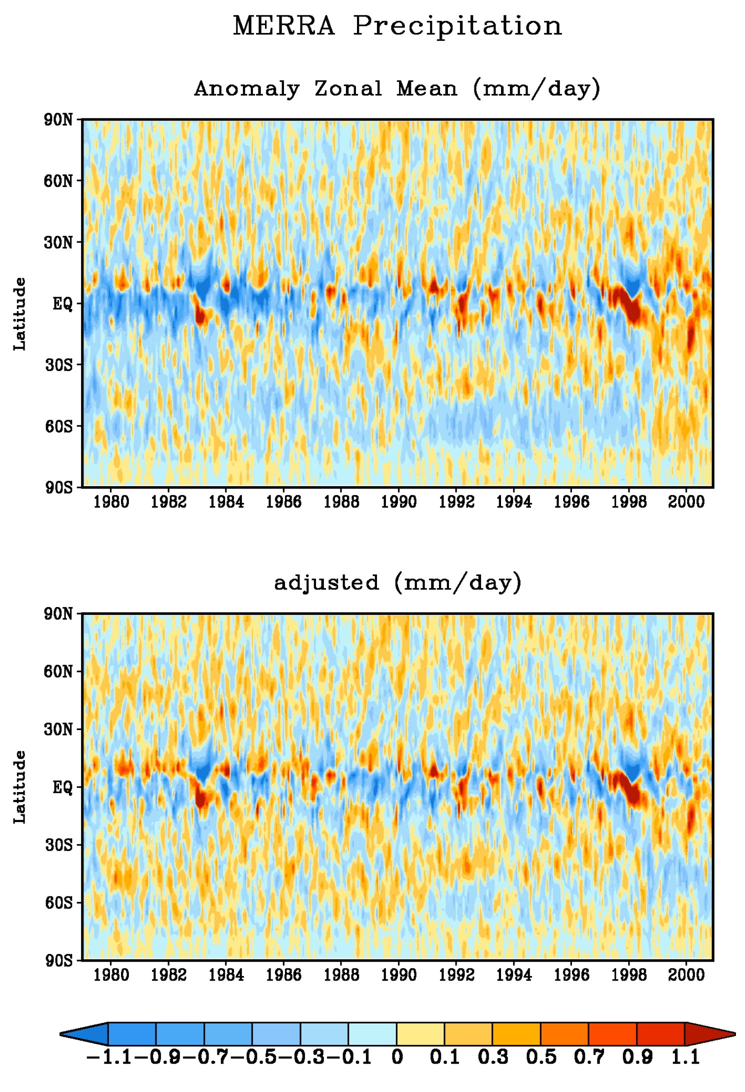
Produce Patches to Homogenize MERRA

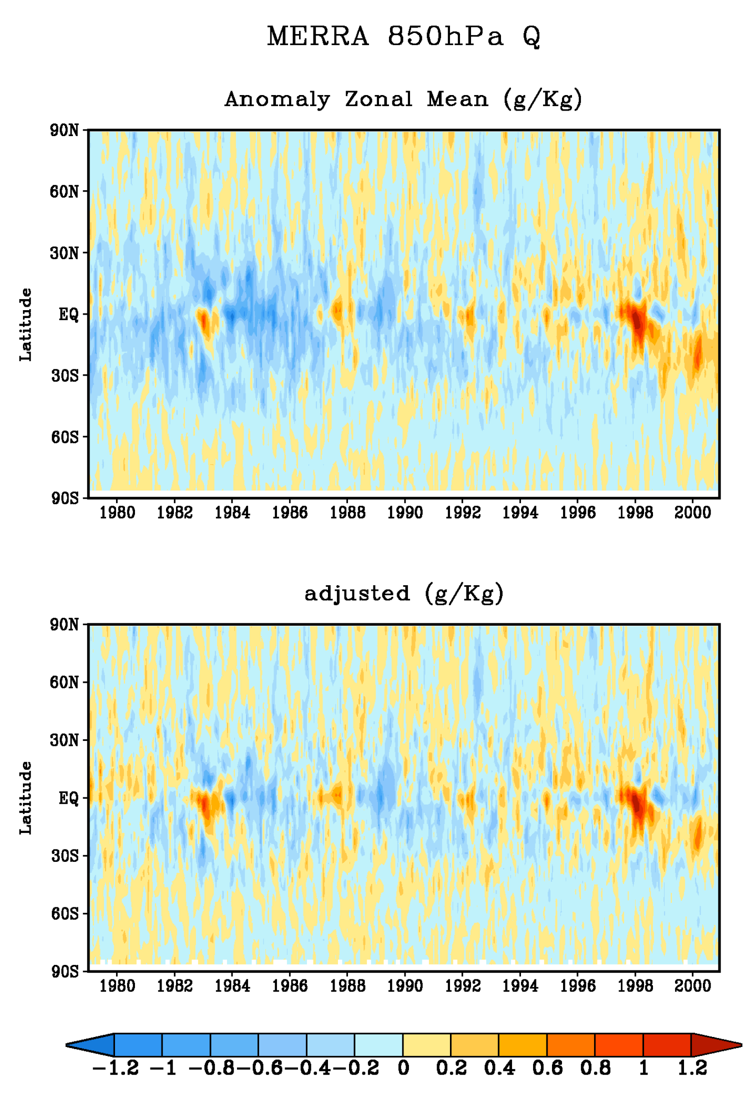


- Patches are applied on the MERRA data before the associated new observation, so the MERRA data in earlier period can be adjusted to match with data in later period.

- A pre-satellite era stream (1970 – 1979) will be produced, so the MERRA data can be extended to 1970. Including this period is important for climate change trend study, as the long-term trend can be distinguished from natural decadal variation by including the 1976 phase change of PDV into the timeseries (Chen et al. 2008).

Simple offset adjustment based on two ROSSes seems working for the global mean timeseries. More ROSSes and more sophisticated method will improve the result furthermore. Ongoing patch generation methods include posterior statistical process and prior model bias correction based on Danforth et al. (2007, 2008).





Summary

- The introduction of new observation types in different time is the major cause of the inhomogeneity in current reanalyses.

- The impact of a new observation type can be systematic, although the distribution usually is not uniform.

- The impacts from different observation types can be very different.

- A plan to minimize the inhomogeneity in MERRA reanalysis has been shown. It can be used as a interim method to improve temporal consistency in reanalysis before we have perfect model, data assimilation scheme and observation.

Two related posters at 239A by Bosilovich et al. and Roberson et al.

Important Climate Issues could be Addressed once MERRA is Homogenized

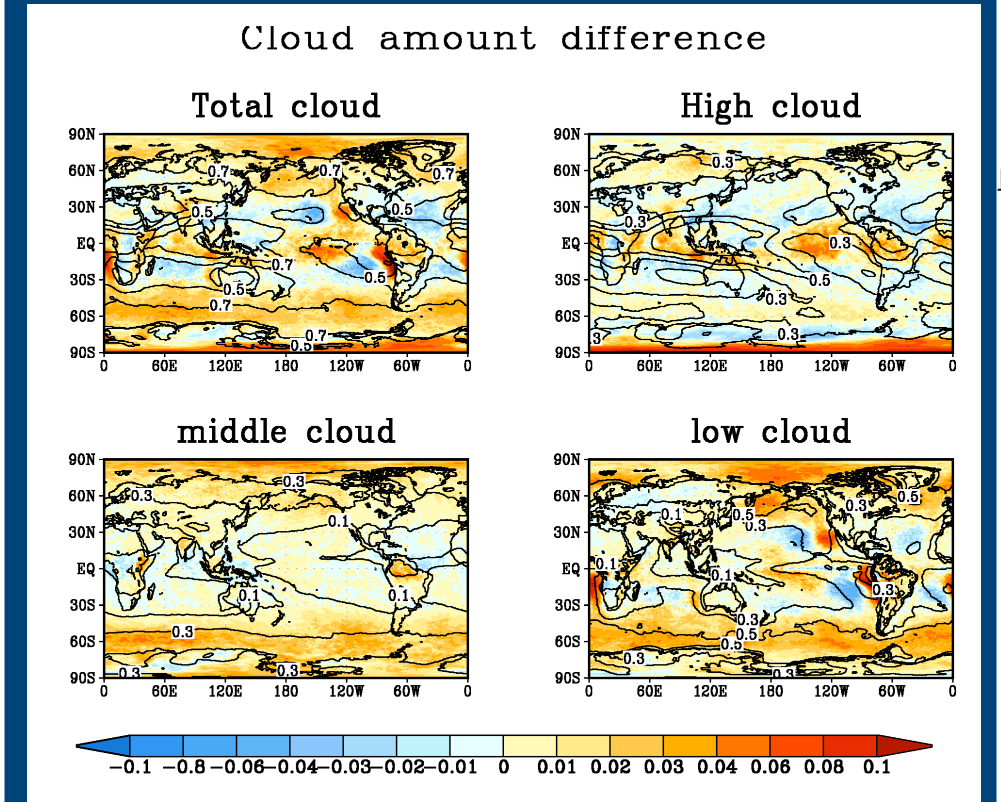
- To accurately reconstruct the climate for the last 40 years.

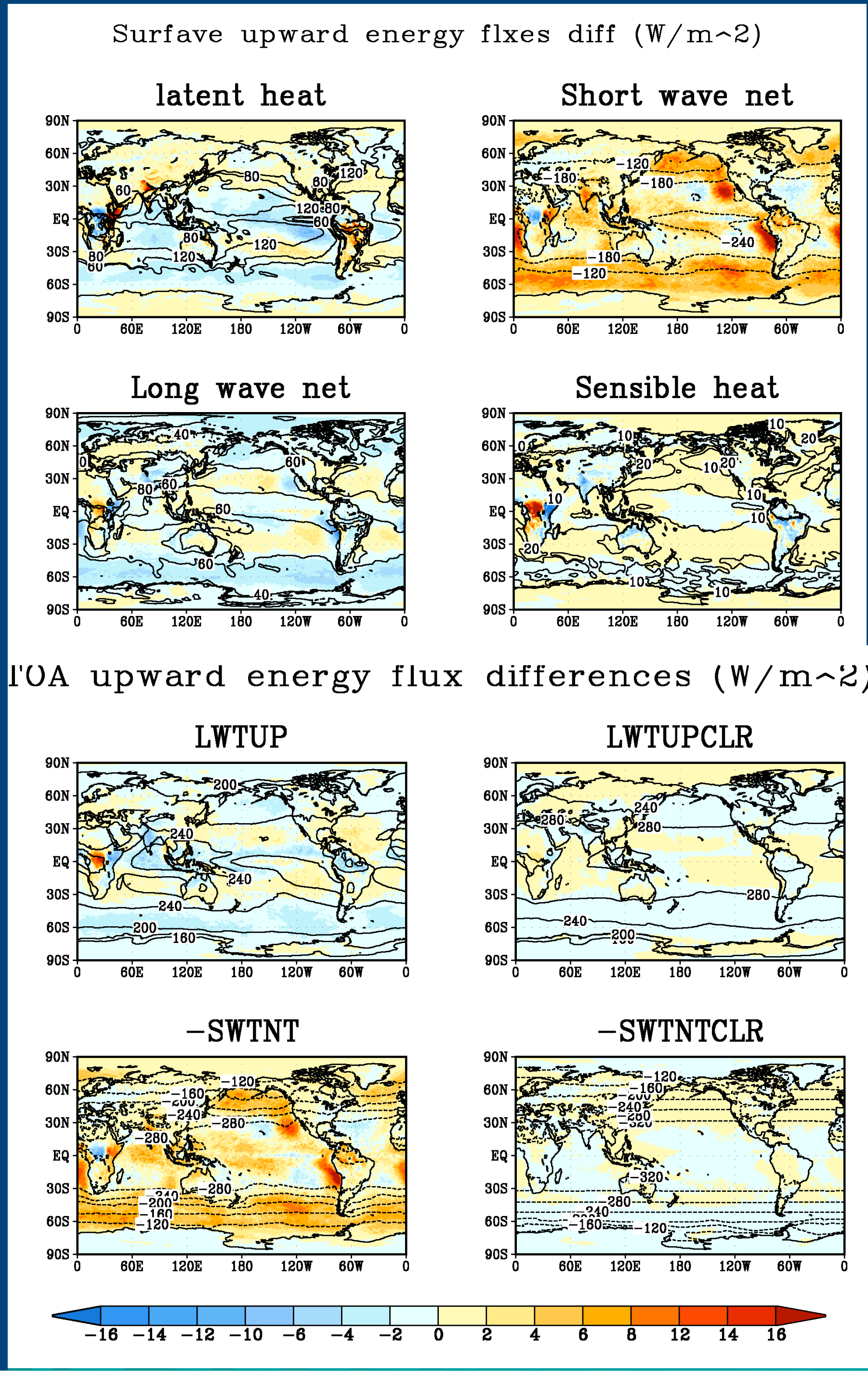
- To clarify the three-dimensional trends of key meteorological parameters in the atmosphere and how these parameters are related to each other.

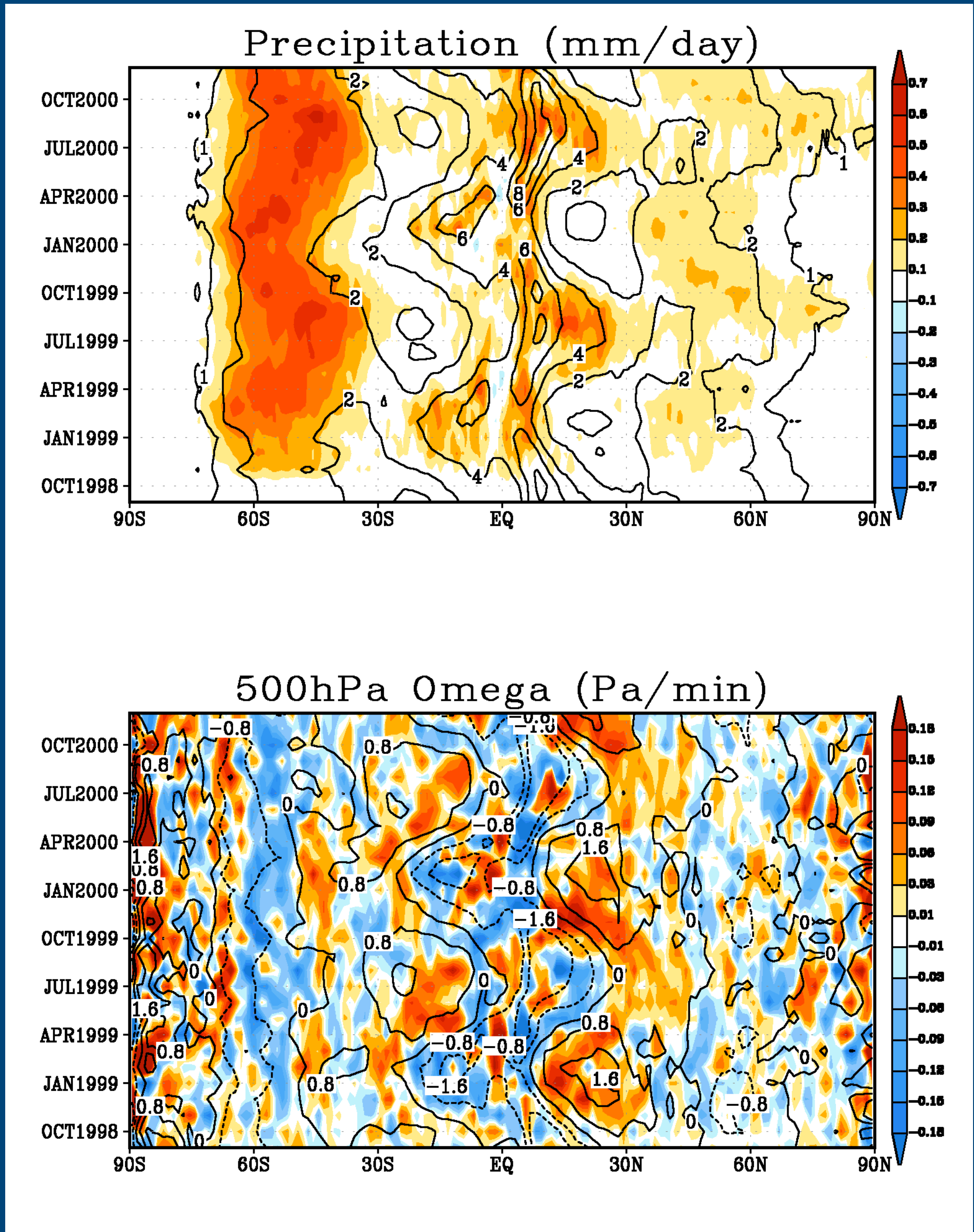
- To improve the understanding of the trend in the water and energy cycles, the fluxes at the top and bottom boundaries of the atmosphere.

The impact on cloud amount is tightly coupled with surface and TOA radiative fluxes.

Color: ave (MERRA – withholding_run)
Contour: ave (MERRA)







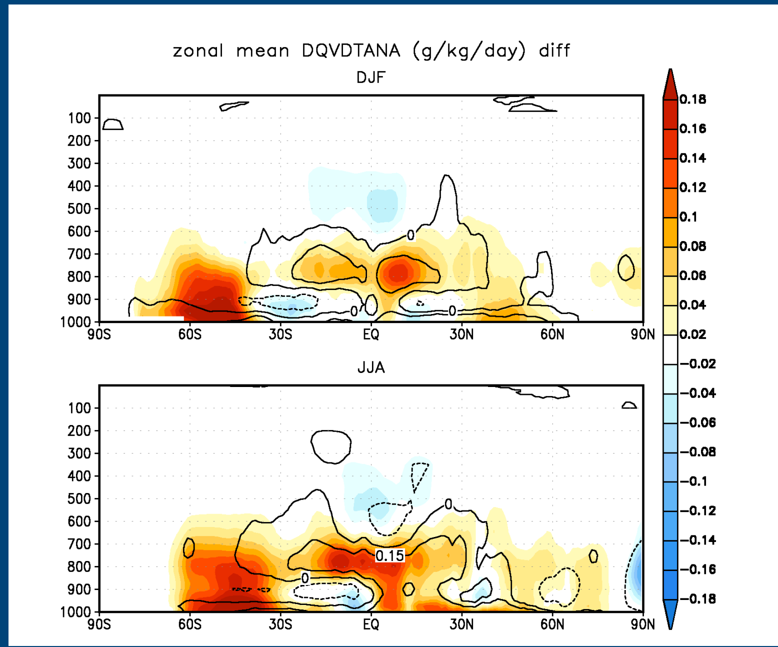
The evolution of the impact in zonal mean precipitation and vertical velocity.

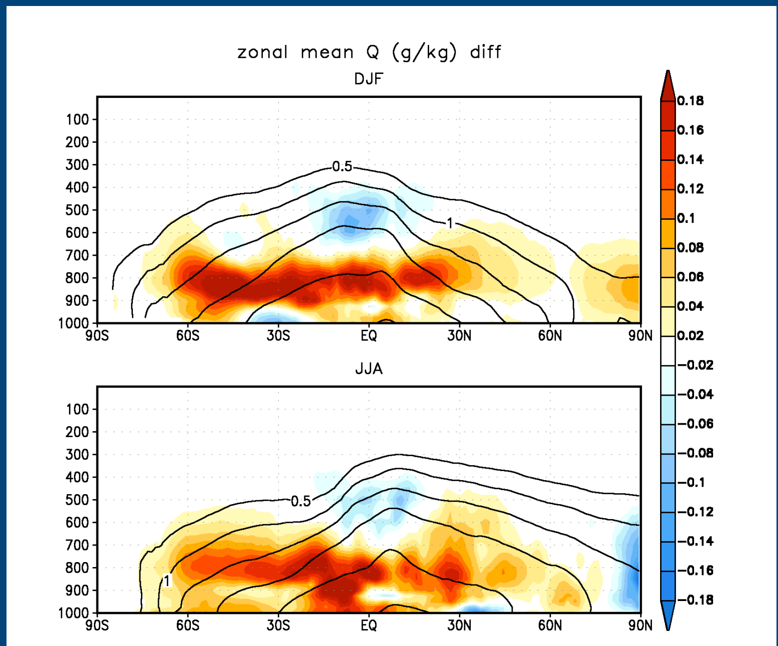
Although the omega filed is a little bit noisy, clearly it is driven by the precipitation field.

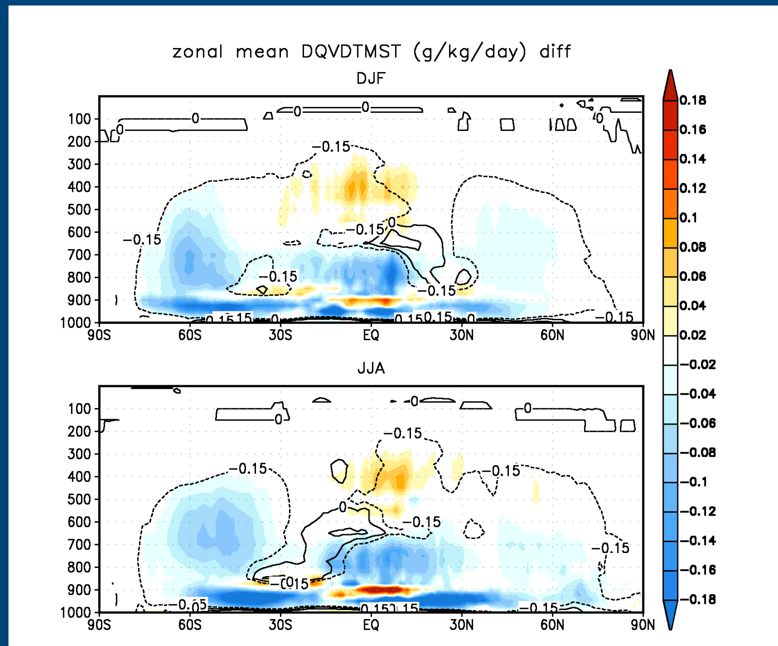
Change of moisture mainly in the lower free troposphere.

Positive moisture increment means additional moisture injected in the system by the data assimilation process.

Precipitation removes the additional moisture added in by the assimilation.







In most areas, the analysis temperature increment tries to cool the atmosphere which is warmed up by the latent heat release driven by moisture increment.